Regional-Dependent Response Functions in Motor Areas Estimated from Multiple Clinical fMRI Measurements

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Target audience Neuroradiologists, Neuroscientists

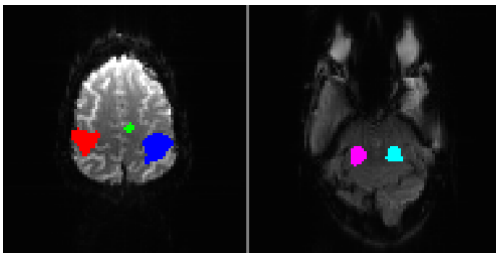

Fig. 1: Cluster of fMRI activation: pmc (red and blue) SMA (green), ac (magenta and cyan).

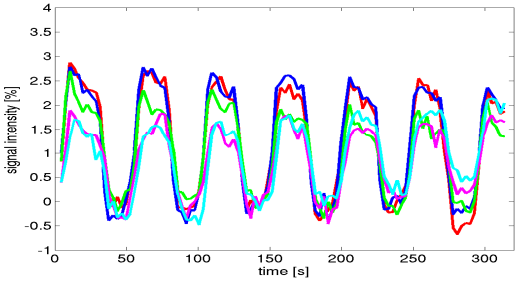

Fig. 2: Averaged signal courses in the selected activation areas without correction of slice position dependent acquisition times. Colors as in Fig 1.

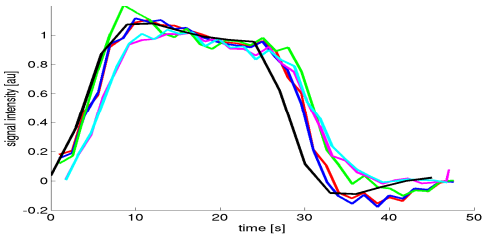

Fig. 3: Averaged signal course within one task cycle under consideration of slice position dependent acquisition times and after normalization. Colors as in Fig.1; in addition, the standard hemodynamic response function used in FSL is shown in black.

Purpose

The results of clinical fMRI measurements show usually a large variablity of the extent of activations and the shape of the signal time course in the activated areas. An averaging over a large number of examinations allows to observe systemaic differences between the signal response function in different brain areas. We used fMRI experiments with a simple motor task to evaluate the average signal time course in the left and right primary motor cortex(pmc), the SMA and the left and right anterior cerebellum(ac).

Methods

Measurements were performed as part of clinical examinations at a 3T MR scanner (Trio, Siemens, Erlangen, Germany) using a 32 channel head coil. 93 fMRI data-sets from patients (16 to 78 years old) without lesions near the motor region and with activation in all five selects brain regions were selected. The protocol consisted of 104 EPI measurements with 30 slices each (TR 3 s, TE 40 ms, Th 3 mm, FOV 240 mm, matrix 96*96). The task design consisted of alternating hand movements. Each single task had to be performed for 24 s. In all motor tasks, the patients were asked to clench and unclench both fists with a frequency of 1/s. Data were evaluated using FSL.

Evaluation consisted spatial smoothing, highpass temporal filtering, movement correction and t-test analysis using the standard hemodynamic response function. The obtained t-maps were evaluated with a home-written MATLAB program. After thresholding with a variable t-value, all local maxima within the t-map were identified and the corresponding clusters of spatially connected supra-threshold voxels were detected without manual interaction. All clusters with a minimal cluster size of 8 pixel were registered. Clusters from the brain areas of interest were manually selected (Fig. 1). Representative signal courses of the selected cluster were estimated by averaging the signal course of 10 voxel with the highest t-values (or less, if the cluster size was smaller than 10 voxel). Only voxel with a mean signal difference of larger than 1% and lower than 7 % between stimulation and rest period were included in the signal averaging process. The averaged time course within one task cycle were evaluated under consideration of the slice position dependent acquisition times.

Results

The averaging process showed a constant signal enhancement level in the pmc and the ac and a decreasing signal enhancement in the SMA (Fig. 2). The signal enhancementen level in the SMA and the ac was only 70 % of the pmc level. After normalization, the signal course analysis showed a delayed enhancement and delayed signal decrease in the ac (Fig.3). A post-stimulus undershoot could only be observed in the pmc.

Discussion This study show differences in the shape and the amplitude of the response function in five brain regions. The results are in contrast to the results reported by Hanakawa et al[1], who examined the response function after a finger tapping task. In their case, the amplitude of motor cortex, SMA and cerebellar area was comparable. The reason for the reduced signal enhancement could be the more simple task (here opening and closing both fists).

Conclusion

The averaging of multiple time courses from clinical fMRI experiments show a reduced signal enhancement during stimulation in the SMA and the cerebellum, which explains the difficulties to find activations in these areas in some patients.

Reference

1. T. Hanakawa et al, J Neurophysiol 2003 89:989-1002